

AMENDMENTS TO THE CLAIMS:

1. (Original) An apparatus for controlling a salient-pole DC brushless motor having armatures in three phases, comprising:

voltage applying means for applying drive voltages to said armatures;

high-frequency adding means for adding high-frequency voltages to said drive voltages;

first current detecting means for detecting a current flowing through an armature in a first phase of said armatures in the three phases;

second current detecting means for detecting a current flowing through an armature in a second phase of said armatures in the three phases;

reference value extracting means for extracting a sine reference value depending on the sine value of a twofold angle which is twice a rotor angle of said motor and a cosine reference value depending on the cosine value of the twofold angle, using a first current value detected by said first current detecting means and a second current value detected by said second current detecting means when said high-frequency voltages are added to said drive voltages by said high-frequency adding means, and high-frequency components depending on said high-frequency voltages;

rotor angle calculating means for calculating a rotor angle of said motor using said sine reference value and said cosine reference value;

three-phase/dq converting means for handling said motor as an equivalent circuit having a q-axis armature disposed on a q-axis in the direction of magnetic fluxes from a rotor of the motor and a d-axis armature disposed on a d-axis which is perpendicular to the q-axis, and calculating a detected q-axis current flowing through said q-axis armature and a detected d-axis current flowing through said d-axis armature based on the rotor angle of said motor which is calculated by said rotor angle calculating means, said first current value, and said second current value; and

current control means for determining said drive voltages so that a q-axis reference current produced by passing said detected q-axis current through a low-pass filter and a d-axis reference current produced by passing said detected d-axis current through a low-pass filter will be equalized to a predetermined q-axis command current and a predetermined d-axis command current, respectively;

wherein said high-frequency voltages are set so that the direction of a revolving magnetic field generated when said high-frequency voltages are applied to the armatures of said motor and the direction in which said motor is rotated by said drive voltages are opposite to each other.

2. (Original) An apparatus according to claim 1, wherein said reference value extracting means comprises means for extracting said sine reference value and said cosine reference value respectively according to the following equations (22), (23)

$$V_s = \int_0^{2\pi} \left\{ \cos 2\omega t \cos \left(\omega t + \frac{2}{3}\pi \right) \cdot I_u - \cos 2\omega t \cos \omega t \cdot I_w \right\} dt \quad \cdots(22)$$

$$V_c = - \int_0^{2\pi} \left\{ \sin 2\omega t \cos \left(\omega t + \frac{2}{3}\pi \right) \cdot I_u - \sin 2\omega t \cos \omega t \cdot I_w \right\} dt \quad \cdots(23)$$

where V_s : the sine reference value, V_c : the cosine reference value, I_u : the first current value, I_w : the second current value, and ω : the angular velocity of said high-frequency voltages.

3. (New) A method of detecting a rotor angle of a salient-pole DC brushless motor having armatures in three phases controlled by an apparatus, said apparatus comprising:

voltage applying means for applying drive voltages to said armatures;

first current detecting means for detecting a current flowing through an armature in a first phase of said armatures in the three phases;

second current detecting means for detecting a current flowing through an armature in a second phase of said armatures in the three phases;

three-phase/dq converting means for handling said motor as an equivalent circuit having a q-axis armature disposed on a q-axis in the direction of magnetic fluxes from a rotor of the motor and a d-axis armature disposed on a d-axis which is perpendicular to the q-axis, and calculating a detected q-axis current flowing through said q-axis armature and a detected d-axis current flowing through said d-axis armature based on the rotor angle of said motor, said first current value, and said second current value; and

current control means for determining said drive voltages so that a q-axis reference current produced by passing said detected q-axis current through a low-pass filter and a d-axis reference current produced by passing said detected d-axis current through a low-pass filter will be equalized to a predetermined q-axis command current and a predetermined d-axis command current, respectively;

wherein said method comprises the step of:

adding said high-frequency voltages, which are set so that the direction of a revolving magnetic field generated when said high-frequency voltages are applied to the armatures of said motor and the direction in which said motor is rotated by said drive voltages are opposite to each other, to said drive voltage;

calculating a sine reference value depending on the sine value of a twofold angle which is twice a rotor angle of said motor and a cosine reference value depending on the cosine value of the twofold angle, using a first current value detected by said first current detecting means and a second current value detected by said second current

detecting means when said high-frequency voltages are added to said drive voltages, and high-frequency components depending on said high-frequency voltages; and

calculating a rotor angle of said motor using said sine reference value and said cosine reference value.

4. (New) A method according to claim 3, wherein said step of calculating said sine reference value and said cosine reference value further comprising the step of extracting said sine reference value and said cosine reference value respectively according to the following equations (24), (25)

$$V_s = \int_0^{2\pi/\omega} \left\{ \cos 2\omega t \cos \left(\omega t + \frac{2}{3}\pi \right) \cdot I_u - \cos 2\omega t \cos \omega t \cdot I_w \right\} dt \quad \dots(24)$$

$$V_c = - \int_0^{2\pi/\omega} \left\{ \sin 2\omega t \cos \left(\omega t + \frac{2}{3}\pi \right) \cdot I_u - \sin 2\omega t \cos \omega t \cdot I_w \right\} dt \quad \dots(25)$$

where V_s : the sine reference value, V_c : the cosine reference value, I_u : the first current value, I_w : the second current value, and ω : the angular velocity of said high-frequency voltages.